Velocity Scan Migrations: A Valuable Addition to the Seismic Interpreter's Toolkit

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SUMMARY

Interpretation of 2D seismic data is often challenging, especially in land data with complex overburden. Out of plane energy, S-wave contamination and low signal to noise ratio often results in a seismic section with considerable levels of uncertainty. A novel, yet often overlooked, method available to an interpreter as part of a processing or re-processing project is the percentage velocity migration scan method whereby velocity fields are perturbed around a centrally picked velocity function and pre-stack migrated to yield a series of differently imaged and stacked sections. These sections, often built from velocity models perturbed to 80-120% from the central velocity field, can then be examined by the interpreter to narrow down levels of uncertainty. Scanning through the sections will potentially enable identification of out of plane energy compared to that in the plane, it may focus events that exhibit unconventional move-out, and can lead to a greater appreciation of event positioning uncertainties.

The velocity scanning method is often used as a processing tool (Gong *et al*. 2018) to help narrow down uncertainty surrounding velocity functions used in the pre-stack migration workflow but is rarely used by a seismic interpreter. With modern computing power and advanced imaging algorithms, this approach can easily be adopted into the seismic interpreter's toolkit. With a delivery from the processing house of up to 20 sections to interpret from, instead of just the one deemed most likely by the processor, this brings uncertainty management into the hands of the interpreter where it can be understood and managed as part of the interpretation flow.

Key words: Seismic, Interpretation, Processing, Depth Imaging

INTRODUCTION

Seismic interpretation can be a challenging endeavour, especially in areas of complicated geology, complex overburden and when working with vintage data, or data with low signal-to-noise ratios. This is especially true of land data with complicated static solutions, weathering layers and changing topography. The levels of uncertainty can be considerable, but the seismic interpreter has an array of tools in the work belt to help distinguish geological layers and unravel the geological story. An often-overlooked interpretation tool is the percentage velocity migration scan method, which can be made available as part of a processing or reprocessing project. This method involves perturbing velocity fields around a centrally picked velocity function and performing pre-stack migration to yield a series of differently imaged and stacked sections. These stacked sections, which can be derived from velocity models varied from 80% to 120% from the central velocity field can be utilised by the interpreter to narrow down their uncertainty in the seismic data.

This method has become possible due to increased power of computing over recent years. Compared to standard processing, this requires as much as 21x more computing power, as the migration may be run 21x over, and all of the post migration processing duplicated 21x as well.

The derived stack sections may help to identify noise, out of plane energy, may focus events that exhibit unconventional move-out and provide a higher level of certainty in an interpretation. This is especially true in areas of high lateral velocity variation and with complex overburden or weathering zones. Up to twenty additional seismic sections may be derived using this method, instead of the one deemed most likely by the processor.

GEOPHYSICS

Processing, or reprocessing, seismic data involves the repositioning of seismic data into its original reflection positions to gain an understanding of the subsurface geological picture. Repositioning is achieved through robust geophysical methodologies derived from over a century of seismic acquisition, processing and oil and gas exploration. Modern computing has seen vast improvements in algorithms, unlocking seismic waveform theory and producing high quality seismic images in fast turnaround times. These methods rely upon the production and refinement of seismic velocity profiles which are derived from the data and utilised in migration algorithms and full waveform inversion. The methods have limitations, especially in areas of low signal to noise ratios, rapid variations in geological velocity and within the weathered zone. This often results in reflectors which are discontinuous, misplaced, or overprinted by offline events or multiple noise. By varying the centrally picked velocity function by up to 20% allows seismic ray travel times to vary and reposition seismic energy, resulting in reflectors that are able to focus or de-focus. This results in events that are strengthened in some velocity scan results and reduce in others. This re-positioning of seismic rays often sees reflectors appear right up to the boundaries of high velocity layers or areas that have rapidly varying velocities.

RESULTS

Reprocessing was carried out for eight seismic vintage lines (1982 and 1986 vintages) within the East Canning Basin in Australia (Figure 1) in June 2022. The reprocessing was carried out from field tapes by Howman Seismic Services and run through a modern pre-stack time migration workflow. Percentage velocity scans were run from 80% of the central velocity function to 120% at 2% increments. Figure 2 shows a seismic section that has been pre-stack time migrated using 80% of the central velocity function compared with the same section that has been pre-stack time migrated using the central velocity function. It is clear that the central velocity function produces the best imaging results with lateral reflectors and discernible geology, however close to boundary of the rapid velocity change the imaging is poor. The seismic section pre-stack time migrated with 80% of the central velocity function results in several reflectors that can be interpreted further towards the high velocity zone.

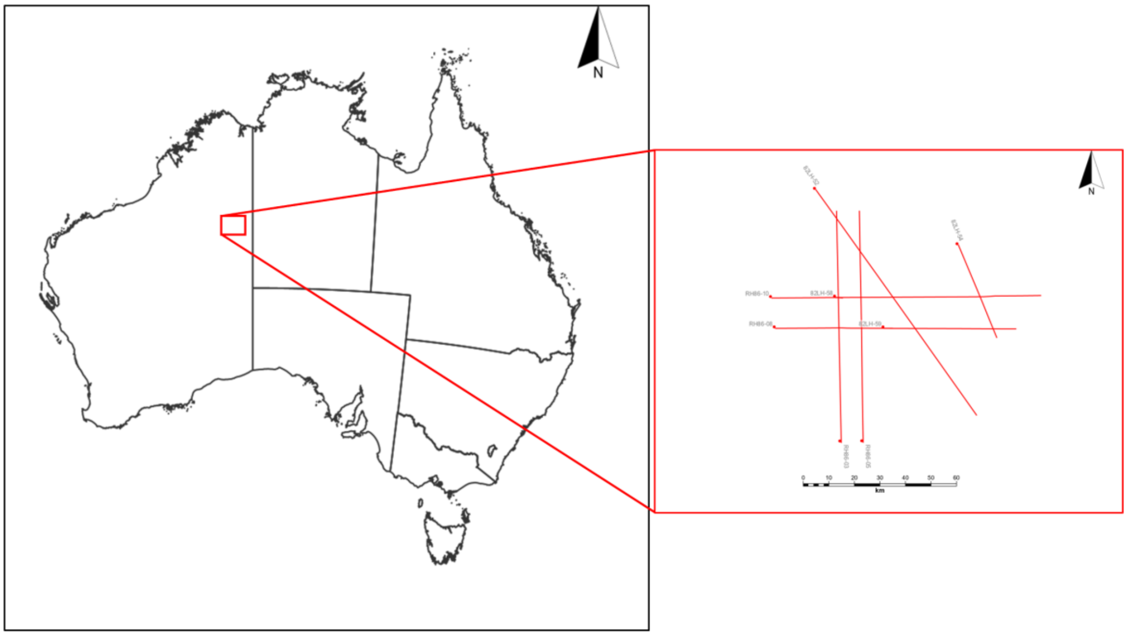

Figure 1. Eight vintage lines were reprocessed over the East Canning Basin area as shown in the red inset map. This area lies near the Western Australian and Northern Territory border.

Another example is seen in Figure 3 where the central velocity function has been picked to produce optimum imaging of the unconformity surface, while the 110% of the central velocity function stack produces a much better image of the dipping reflectors truncating against this unconformity. Any attempt to put a velocity break this sharp into a velocity model would result in migration noise, and a result that would not be as good as either result separately.

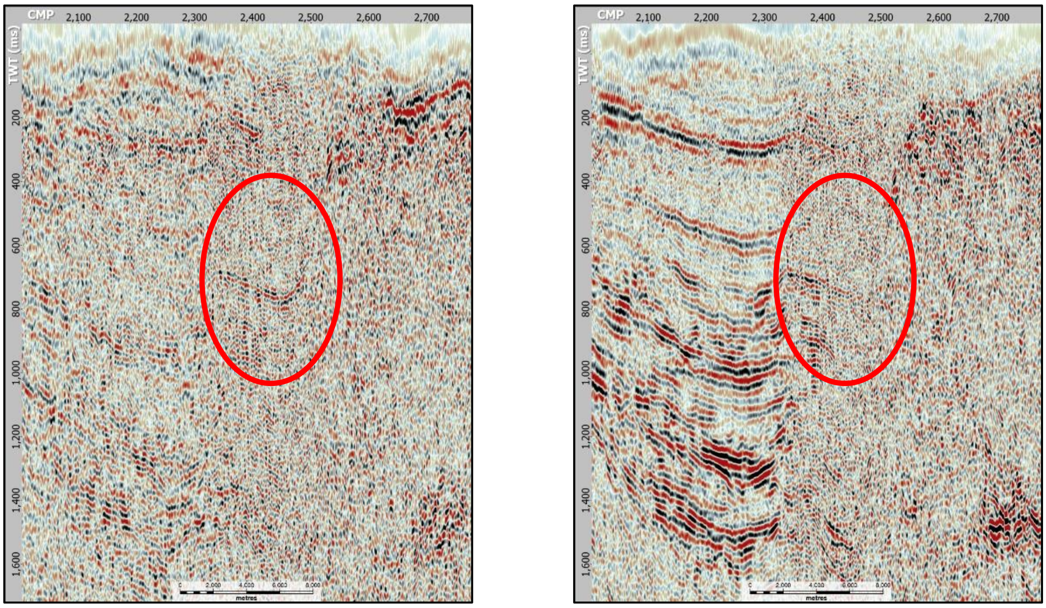

Figure 2. Seismic section pre-stack time migrated at 80% of the central velocity function (left hand side) and the same seismic section pre-stack time migrated using the central velocity function (right hand side). Red ovals highlight areas of marked change between the sections.

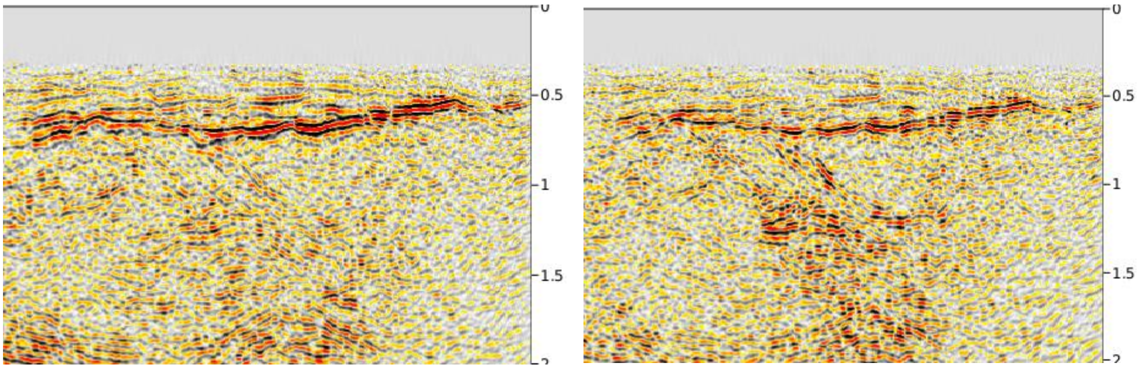

Figure 3. Seismic section pre-stack time migrated using the central velocity function (left hand side) and the same seismic section pre-stack time migrated using 110% of the central velocity function (right hand side). The left hand stack images the unconformity, while the right hand stack images better below.

Utilising these methods, the seismic interpreter can, with higher confidence, delineate geological boundaries and infer geological reflectors, without having these decisions made for them by processing contractors, who are often not geological experts in the particular region of interest.

CONCLUSIONS

The percentage velocity migration scan method allows the seismic interpreter access to an additional tool to reduce uncertainty levels in their seismic interpretations. Using this method, velocity fields are perturbed around a centrally picked velocity function and pre-stack migrated to yield a series of differently imaged and stacked seismic sections. This overlooked method, whilst not new, is available to the seismic interpreter during processing and reprocessing projects.

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REFERENCES

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